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A Global Decision Support System for Garment Manufacturing by Using Genetic Algorithm

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Abstract: In the recent years, each industry has to face the situation of making the decisions from global markets, especially the industries within lower technicality. These industries earn money hardly in the perfectly competitive markets. Sometimes, decision makers have to decide how to allot orders in the different factories because of distinctive requests from individual consumer. It is necessary to find a way to help managers with making a decision and allotting orders effectively.

The purpose of this study tries to develop a decision support system (DSS) to help the managers and decision makers of a real garment industry In Taiwan to decide order allocation, and we used genetic algorithm (GA) for analysis tools and results would be showed by visual graphs to assist managers in decision making. By decision support systems, managers and decision makers might decide order allocation quickly and save the costs.

Finally, the decision support system results in a visional frame within lowest cost, and managers decide order allocation with effectiveness by graphs. With this information, decision makers might make different decisions in unlike situations for dissimilar goals. The system had developed to be used easily and suitable to the garment industries and other similar manufacturing industries.

Keywords: global industry, garment industry, DSS, GA.

I. Introduction

It's very important to make a suitable decision within effectiveness for industries, especially in the global industries. In the past approaches, many scholars and senior decision makers always make decisions by their brains with professional experiences and some information including balance sheets and etc. And they respected to get competitive advantageous positions if decisions could fulfill demands of consumers [1-4]. By this traditional method to make decisions has become more difficult and inefficient in recent years because sciences and information technology grow up fast causing influencing factors excess and complex. Many enterprises have to make efforts on the global logistics management (GLM) for raising their competitive capability, but there are still some problems to be solved.

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In generally, benefits of consumers from a competitive market are limited. It is harder to obtain extra profits than to reduce costs. The proprietors of global industries always try to find a way to reduce cost without high interests. Some scholars proposed that using resources around the whole world properly could decrease costs [5]. Taking the garment industry in Taiwan for example, it has lower entry barriers and a new competition enters easily with advanced technology so if the global garment industry want to move manufacturing factories from Taiwan to other countries, it is easier than other industries. To find cheaper labors is necessary for garment industry. This is why many global industry move factories to developing country to get some resources [6].

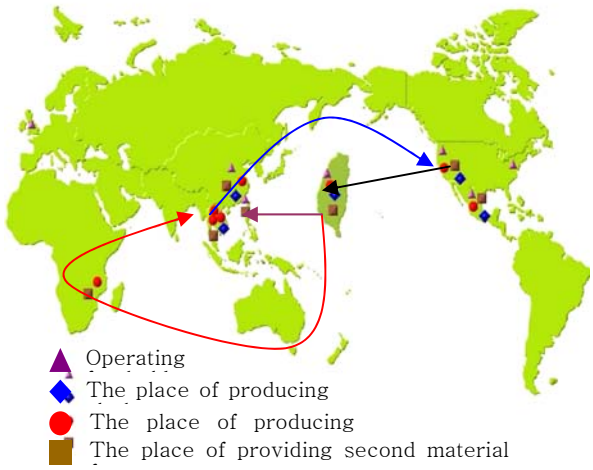

Fig. 1 The global sketch of a real famous garment corporation in Taiwan

As Figure 1 shows, country of origin, main markets, and manufacturing factories are in the different geographical locations, even in the different countries. The data presented in Figure 1 was collected from a real global garment corporation in Taiwan and triangles represent sales offices, the rhombuses represent factories producing fabrics, the circles represent for factories producing garments, and the squares stand for places of providing raw material for garment.

Global resources bring the chance to reduce costs and cause some problems. To transport goods by freighters often takes long time. In global competitive markets, the most

important job is to satisfy with customers including productions and delivery date. Reducing delivery time and quickly responses would let industry get lower costs [7]. Thus, many decision makers always try to make a decision for allotting orders with effect to different manufacturing factories, and the decision must conform to minimum cost. In traditional method, making a decision for order allocations wastes time and often be impacted by decision makers' and managers' personal experiences. There are lots of influencing factors affecting a decision making. If decision makers made a wrong choice, the final result causes additional costs. "Decision Support System, DSS" was developed for assisting decision makers and senior managers to make a correct decision for corporation goals, and it also solve the problems with uncertain and blurred elements [8]. With electronic technology, DSS could process complex and a great quality of factors. Thus, DSS [9, 10] would be a important role in the modern garment industry.

In this study, we tried to develop a global decision support system for a real garment corporation in Taiwan. The senior managers in the corporation try many ways to conduct electronic systems into business strategies, especially in decision making. They respect that could get a helper to make a decision within the goal of lowest cost. Because of lowest cost, we let "Genetic Algorithm, GA" [11-19] be a analytic tool for the decision support system. After executing the system, the results would be presented by Gantt charts and lists, and decision makers and managers could make decisions effectively by charts and lists.

The rest of this paper is introduced as follows. Section 2 depicts slightly overviews of "Genetic Algorithm" and "Decision Support System". The approach of this study is described in Section 3. Section 4 would describe the experimental results. Finally, conclusions are presented by summarizing the findings in Sections 5.

II. Genetic Algorithm (GA) and Decision Support System (DSS)

II. 1 Genetic Algorithm (GA)

Genetic Algorithm (GA) was developed by Holland. GA is usually used to find the best solution or process complex problems by the different ways with the rules as imitating organisms' evolution. It is just like a learning cycle and it is always executing until satisfying the goals of decision makers need. After each round of checking results, the better result would replace the bad one within conditions made by senior managers. The processing of GA is presented as Figure 2 shows as following.

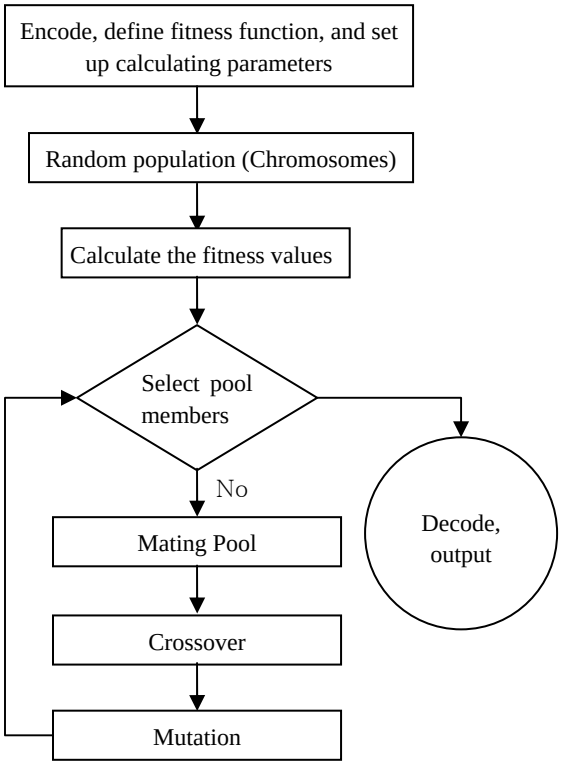

Fig. 2 The flowchart of GA

GA has applied to lots of fields, such as system intrusion detection [20], production scheduling [21], and others [22]. Maybe the subjects are different, but it confirmed GA could process complex data.

The characteristics of GA different from traditional algorithms were defined as following [23].

1) GA is more suitable for solving some complex problems because it uses encoding string to calculate, and it won't be limited by some real condition of parameters.

2) GA is a better tool to find a global optimization than other algorithms because GA is used to calculate from many of points to find the best solution.

3) While calculating, it is necessary to add some extra numeric to find the best solution. The final result is impacted easily by additional values. GA calculates with information created by previous generations.

4) GA suits different kinds of problems because it randomizes chromosomes for copulations and mutations.

In some studies, GA could execute varied phenotypes in multi-processing units so it would handle a large number of data [24].

II. 2 Decision Support System (DSS)

The concept of DSS was presented by Scott Morton [25] and the system was called "Management Decision Systems". The main characteristic of systems is to assist decision makers to use data and models to solve unstructured

problems by interactive decision systems. As figure 3 shows, there are three principal elements within DSS, including Data base Management Software (DBMS), Model Base Management Software (MBMS), and Dialog Generation and Management Software (DGMS) [8].

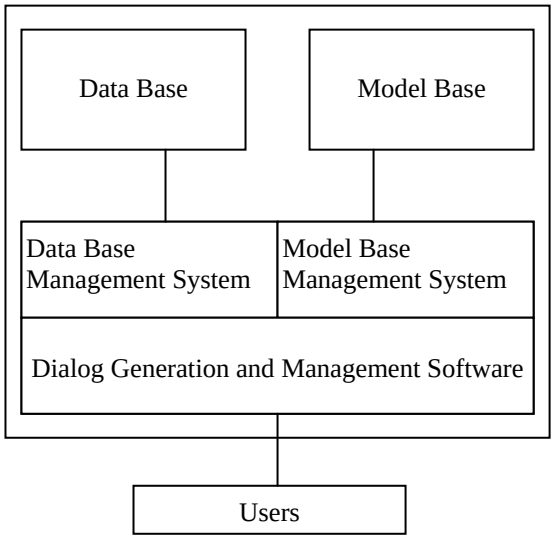

Fig. 3 The structure of GA [8]

The purpose of DSS is not to do decisions for senior managers or decision makers. It always creates some information by tables and lists to assist senior managers to make a correct decision. It also helps decision makers to settle the semi-structured and unstructured problems [26, 27]. DSS can calculate by different formulas and fit it to the real situations with electronic systems because the conditions of global industries always change.

III. Approach

III. 1 Influencing Factors of the Decision

There are about some important influencing of a order allocation decision, including competitive strategies of business, global competitive environments, tariff duties and quotas, elements of consumers, elements of politics from each country, capacity, delivery time, costs, technology of manufacturing factories, and elements of factories' operations.

Each kind of industry has own goal of strategy, for example lowest cost, and the goal also impacts the final decision. The final decision would influence some decisions of partners from supply chain. Quotas could impact deeply on global garment industry from each country, especially in Taiwan. Since 2005, World Trade Organization (WTO) had announced canceling quotas measure of the whole world. The policy has exchanged import and export of garment industry.

In global garment industry, to satisfy demands of consumers and deliver goods on time are two major factors to enhance competitive capabilities. If senior managers wants to get lowest, there are some factors had to be solved, including order allocation. To shorten delivery time could reduce correlative costs.

III. 2 The Structure of DSS

After interviewing with senior managers from a real global garment corporation, we synthesize the documents and factors provided by managers. We built a model with these factors and the model is presented as figure 4 as following.
As we have said above, there are many complex elements that could influence our decisions and every element also could influence one another. Therefore, we select the strategies by gradation.

In the first stage, this is a very broad field of making decisions. This stage is aimed at the goals of the organization and competitive strategies. Senior managers have to consider more and extensive factors such as the competitive strategy of the organization, global competition and internal constraints and select the supply chain strategy. In this stage, it pertains to long-term decisions. On the contrary, as short-term decisions, we regard as static.

There are different features and technology such as factors of customers between each factory. In the second stage, we consider some factors including production technology, factors of customers, quote and rewards, and regional demand to weed unsuitable factories artificially. Through the influence of these factors, we select some suitable factories. In this way, we could reduce complication of computation.

After second stage, we select parts of the factories because of some factors, but it may lead to the high cost. In the third stage, we balanced the capacity. Therefore, we select the factories with capacity surplus and less utilization ratio to balance the capacity and find the suitable factories effectively.

In the fourth stage, we take cost minimum as the goal to select the most applicable factory. Therefore, we draw on systematized tools like Gantt chart to simulate the strategies and find the most applicable factory. Also, it assists senior managers or decision makers in making decisions.

In line with the rules of how an organization works and consulting some excellent documents, we come up as figure 4 showing.

III. 3 Encoding and Calculating

Before beginning to calculate by using GA, we have to define and encode some elements. In this study, each order was presented by each gene and denoted the number for each order as A, B, C, and etc. The fitness function combined by "Cost Based Measure, CBM" and "Due-date Related Measure, DRM" can be presented as

$$F = \sum_{i=1}^{n} \left[w_1 CBM(i) + w_2 DRM(i) \right] \quad (1)$$

and w_1 is the weight of CBM and w_2 is the weight of DRM. Both of w_1 and w_2 are binary.

$$CBM(i) = M_i + T_i + L_i \quad (2)$$

where

M_i is the raw material cost of i_{th} order.

T_i is the transportation cost of i_{th} order.

L_i is the labor cost of i_{th} order.

If the goods deliver late, the additional cost can be expressed as

$$DRM(i) = \max\left[(C_i - D_i), 0\right] * Q_i * U_i * \mu \qquad (3)$$

where

C_i is finish time of i_{th} order.

D_i is expected delivery date of i_{th} order.

Q_i is the amount of garments of i_{th} order.

U_i is the price of each garment of i_{th} order.

μ is the punitive factor behind time.

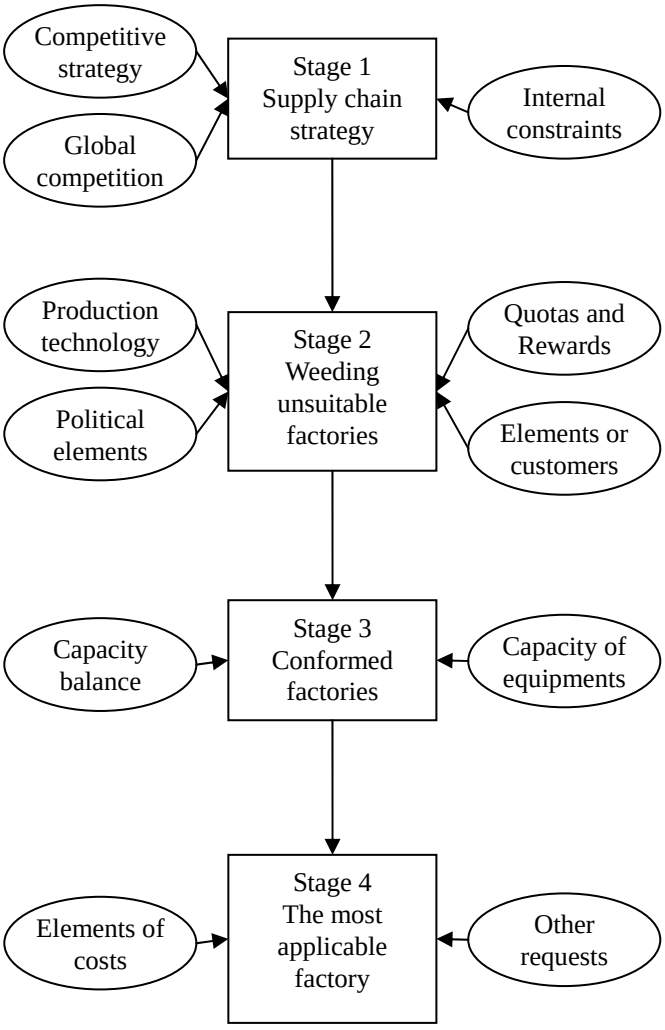

Fig. 4 The processing of DSS

IV. Experimental Result

In this study, we used Microsoft Visual C++ to develop the global decision support system and the operation system was Windows XP. We used GA to be a analytic tool, population size was 100, crossover rate was 0.8, mutation rate was 0.05, and generation was 100. Because of complex types of real data, we wanted to present the status of data as true as possible, and then, we encoded in enumerating was employed rather than in binary. We used two-point crossover and two-point mutation to find the final solution.

The system always executes based on “lowest cost” and it also provides two goals for decision makers, including “the highest capacity utilization rate” and “the highest on-time delivery rate. If a factory can not fulfill with requirements of orders, there is a red vertical line shown up and warn the decision makers.

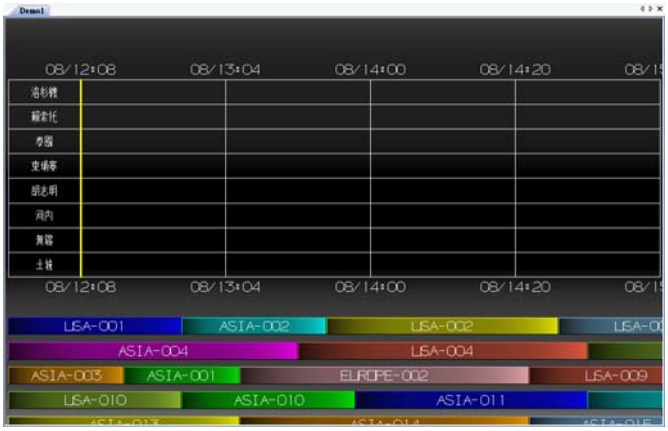

Fig. 5 The initial frame of global garment DSS

This system provides “semi-manual” and “semi-automatic” methods to executive for decision makers. As figure 6 shows, if there are some orders important, decision makers could put them into the schedule. After scheduling by decision makers, the system would arrange remainder orders. The red line in left of figure 5 means the final time when fulfilling contracts, and the green line means time to start manufacturing.

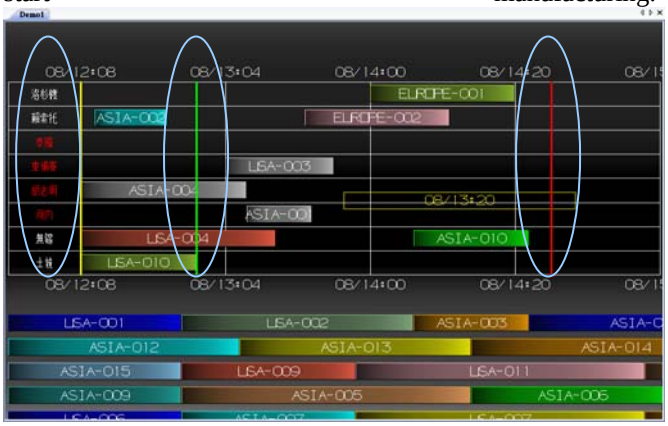

Fig. 6 Scheduling by semi-automatic

Maybe there are some importers who don't want goods manufactured in some countries. When we chose one tag as figure 6 shows, the order called "LEA-002", the system would show out suitable countries for requests of consumers within white words.

Fig. 7 The frame of global garment DSS after scheduling

When users had decided some important orders, they could arrange surplus orders into fit factories automatically. As figure 7 shows, users could press "Agent" and the system would schedule the orders. This system also provides a function that when users press the right button on the mouse, we can check information of data including costs, numbers of orders, kinds of goods, information of consumers, and etc. As figure 8 shows, information would present as a list. Decision makers or senior managers could compare information and make a manufacturing decision correctly and quickly.

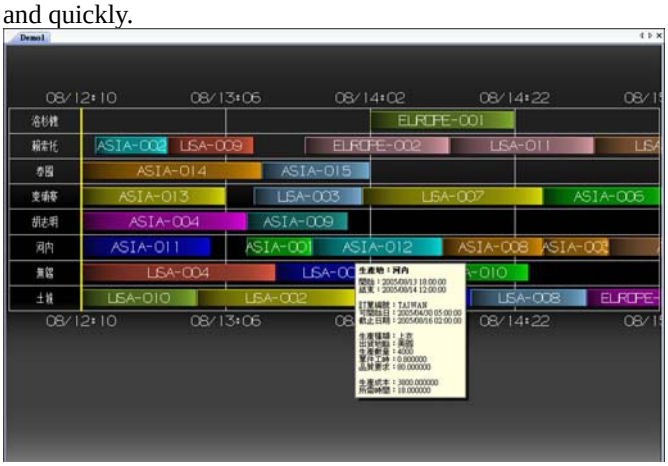

Fig. 8 Information of a order

V. Conclusion

We had built a global decision support system for decision makers from a real global garment corporation, and the system could assist decision makers and senior managers to make a decision of order allocation within effectiveness. And this system always executes based on lowest cost.

The global DSS contains three major elements, including input databases and parameters, the analytical tools, and the presentation mechanism. The input data was collected by Enterprise Resource Planning (ERP) systems of a real garment corporation. Because there are too many factors with making a decision, we used genetic algorithms (GA) to be a analytical tool. GA is a useful tool to solve the problems within complex factors.

In the end, tables and Gantt charts could be reference materials for making decision by decision makers. The system is developed to be easy and quick to use. And it is also suitable to the global garment industry for order allocation. In the future, we could join more factors, for example, extra flight brings lots of additional cost. With more factors, the system could simulate a real situation of global garment industry. However, each algorithm has own-self defects. If we can't accept too many inaccuracies, we maybe focus on using improving algorithms for analyzing tools in the future.

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